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DISCLAIMER

CHANGES IN THE PARTICLE SIZE DISTRIBUTION OF LX-17 SAMPLES INDUCED BY 5- to 8-GPa PLANAR SHOCK WAVES

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Samples of LX-17 explosive were shocked to 3.5, 5.0, 5.7, 6.5, 9.4, and 10.6 GPa by the impact of thin flyer plates accelerated by an electric gun. The samples were held in a fixture designed to allow recovery of the shocked specimens. The specimen shocked to 10.6 GPa reacted strongly enough to pulverize, but not burn the sample; the other specimens were recovered intact. Particle size analysis performed on the recovered samples after the binder was removed by a solvent showed a reduction in mean particle diameter with increasing shock pressure.

1. INTRODUCTION

A knowledge of what happens to high-explosive crystals as they are shocked to higher and higher pressures is useful in learning about the mechanisms of shock initiation. For this study we have shocked samples of LX-17 to pressures of 3.5, 5.0, 5.7, 6.5, 9.4, and 10.6 GPa. A 1.27-mm-thick flyer from an electric gun was used to create the shock wave.

2. LX-17 EXPLOSIVE

LX-17 is a plastic-bonded explosive consisting of 92.5% TATB and 7.5% Kel-F 800. The LX-17 used in these experiments was Mason and Hanger-Silas Mason Blend 38, lot number 4074-145-01. The density was 1.91 g/cm^2, nominal density for LX-17.

3. RECOVERY APPARATUS

A schematic drawing of the recovery apparatus is shown in Fig. 1. The heavy steel container keeps the weaker inner parts from flying apart. The sample is surrounded and backed by materials of the same acoustic impedance as the sample. With many pieces inside the steel container, the momentum is carried away and gaps are allowed to open rather than permitting tensile waves to travel back into the sample. The sample consisted of two machined cylinders 12.7 mm in diameter; the first was 1.0-mm thick, and was backed up by a piece 2.0-mm thick. The two parts were recovered separately so that

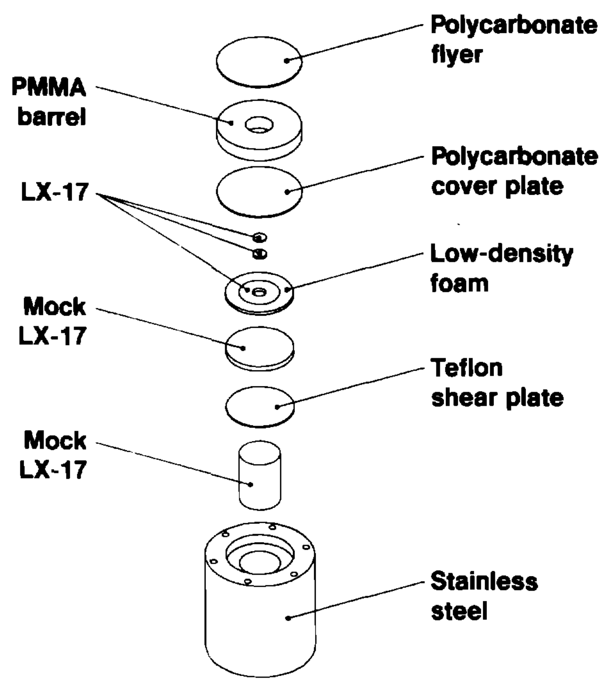

FIGURE 1
Recovery apparatus with heavy steel outer container and inside parts of materials with mechanical properties similar to LX-17. The large cylinder of mock LX-17 carries the momentum in the shock wave away from the samples.

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damage in the first 1 mm could be measured independently from that deeper in the sample. For firing, the container is inverted so that the inner parts are held together by gravity.

4. ELECTRIC GUN

A 0.04-mm-thick, 25.4-mm-square Al foil is burst by the discharge from a 56-μF capacitor bank, driving a 1.27-mm-thick, 25.4-mm-diam polycarbonate flyer to the target. This drives a shock pulse of about 400-ns duration into the sample. This electric gun was previously described by Weingart el al.[1]

5. EXPERIMENTS

Table 1 is a summary of the shots fired. A 12.7-mm-long by 25.4-mm-diam barrel was used for shot 10604. Barrels 5.6-mm-long by 25.4-mm-diam were used for all other shots. A DYNA-2D computer model of a 5.0-GPa shot showed no attenuation of the shock front as it passed through the sample.

6. ANALYSIS

The density of the recovered samples was determined by Archimedes' method of measuring first dry, then wet weights. The binder was then dissolved from the samples. Random samples were selected from the dried powder and mixed. The particle size was then determined with a Bausch and Lomb "Omnicon" image analyzer. This machine randomly selects 6,000 to 10,000 particles of each sample to be measured. The results are summarized in Figs. 2–5.

In all of the plots, the data for the 4.97-GPa shot do not seem to fit the trends of the other data. The reason is unknown, and we will repeat the shot to look for clues to the answer. We plan also to investigate more thoroughly the effects of shocks just below the detonation threshold of LX-17.

DISCUSSION

Our results show that the shock passing through a sample of LX-17 breaks the TATB crystals into smaller pieces. As the shock pressure approaches the detonation threshold, the mean particle size and median particle size decrease by 25% in parts of the sample. The standard deviation from the mean approaches 33%. A knowledge of these processes will give clues to the physical mechanisms of detonation.

TABLE 1. Capacitor charging voltage, flyer velocity, and calculated pressure for each shot of this series.

Shot	Capacitor charge (kV)	Flyer velocity (km/s)	Shock pressure (GPa)
10599	12.10	1.33	3.50
10600	15.00	1.72	4.97
10601	18.90	2.07	5.69
10602	24.50	2.39	6.47
10603	33.00	2.5*	9.4*
10604	24.90	2.87	10.58†

*The values are approximate because the transmission line shorted during the shot, which decreased the velocity by an unknown amount.

†Significant reaction occurred and the sample was broken into very small pieces.

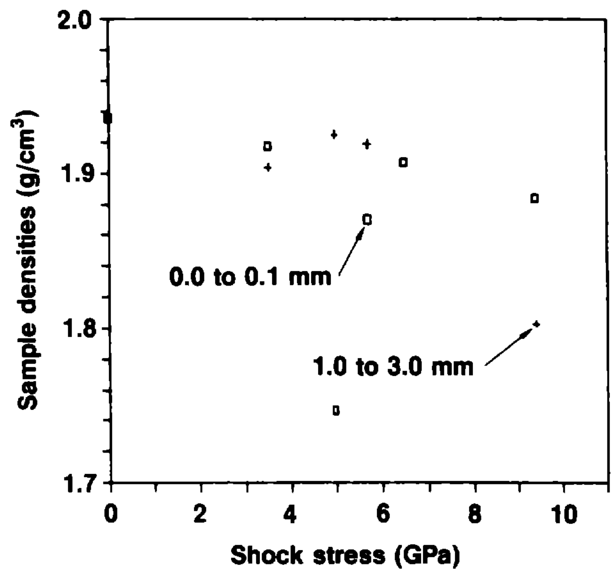

FIGURE 2
Densities of the recovered samples compared to the unshocked control. The densities of the recovered samples decrease as the shock pressure increases.

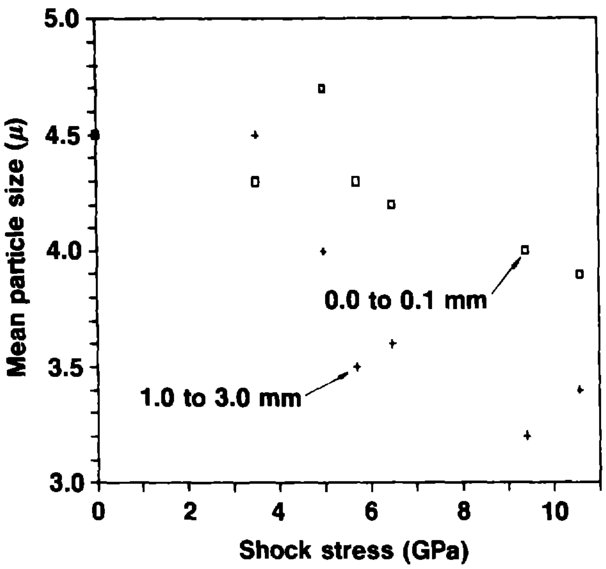

FIGURE 3
Mean particle size. The material in the first millimeter shows a slight decrease in particle size with increasing pressure, while the material 1 to 3 mm from the front surface shows a much greater difference. There is only one particle size given for the shot at the highest pressure because both target parts were broken into small pieces and mixed together. Particle size analysis on the 5.69-GPa shot was repeated to give an idea of the reproducibility of the measurements.

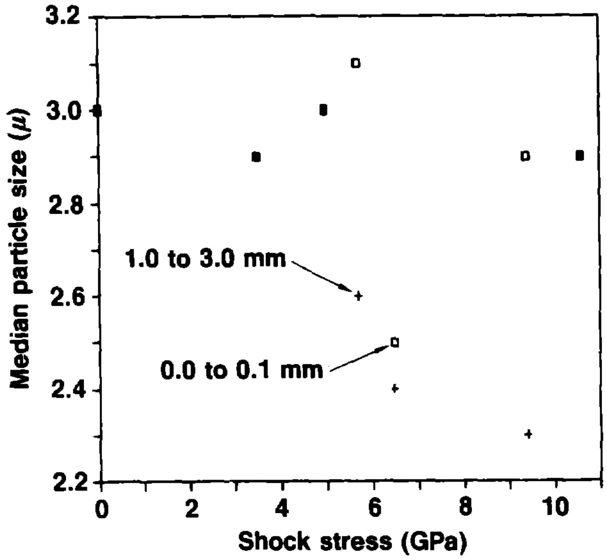

FIGURE 5
Half of the particles in each sample are smaller than the median particle size. The general trend is toward a smaller particle size at higher shock pressure. There is a smaller change in the first millimeter of sample than in the material behind it.

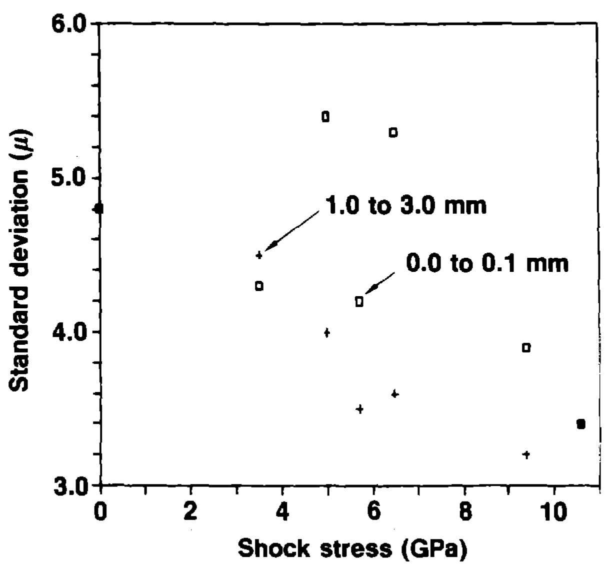

FIGURE 4
Standard deviation of the particle size distributions; 70% of the material lies within one standard deviation of the mean size. The distributions are skewed toward heavier particles.

ACKNOWLEDGEMENTS

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1. R. C. Weingart, R. S. Lee, R. K. Jackson, and N. L. Parker, Acceleration of thin flyers by exploding metal foils: application to initiation studies, in: Proceedings Sixth Symposium (International) on Detonation, Report ACR-221 (Office of Naval Research, Arlington, 1976).